Introduction to Astrophysics

ASTR204

Instructor Info

Prof. Karen Masters (KLM)

Student Hrs: Book me at `https://calbird.com/karen/1136`

Observatory A

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Course Info

Prereq: PHYS 106 (or co-req in BMC equiv.)

Tues & Thurs

10.00-11.30am

TBA

Lab Info

Self scheduled

Five evening lab sessions

Observatory

TA Info

Emily Harrington

Homework Help: TBA

TBA

Overview

Astronomy 204 is the Introduction to Astrophysics class required for both astronomy and astrophysics majors and astronomy minors. This course provides a broad physical foundation to astronomy and astrophysics and serves as a prerequisite for the study of advanced topics. We will cover the physics of stars and stellar remnants, nebulae and star-formation, as well as an introduction to Galactic and extragalactic astronomy, and the basics of observational and theoretical cosmology.

Another goal of ASTR204 is to provide an introduction to tools of the research scientist. You will learn the basics of how to manipulate astronomical data in python. We will learn some tools of the observational astronomer through the completion of observational projects. These will require additional instruction in the use of telescopes during evening Observing labs (dates TBC). We will also begin to learn about how to read the astronomical literature,

Material

Textbook

Stan Owocki *Fundamentals of Astrophysics*.
This is a newly release textbook which aims to cover all of astrophysics at the level suitable for a 1 semester class - exactly like this class (although ordered differently). It is available both in paperback and an e-book, and will be held on reserve in the Library. For each topic further reading will be noted out of this book, which sometimes treats things in a different way and as such is highly complementary to lecture notes.

Grading Scheme

30%	Homeworks
30%	Observing Assignments (see last page)
10%	Review Paper (see below)
10%	Participation and Contributions
20%	Final Exam

Homework, Lab Reports and Review Paper

This class is designed around regular out of class work. Either a homework or a lab report will be due every week at 2pm on Thursday. You will not be able to participate fully in class if you do not keep up with the Homework/lab schedule. A lot of learning takes place in the process of doing science, not in simply getting a numerical answer as quickly as possible written work will be evaluated as such. Please show your work cleanly and neatly, and help us to give you partial or full credit! The expectation for homework, lab reports and other written work, is that a physicist will be able to understand exactly what you're calculating and why without looking at the question you were asked.

One assignment, will be reading a scientific article concerning a topic in astrophysics of your choice. You will write a 3 page summary of the paper, including any relevant necessary background. You will give short (~ 5 min) presentation of the paper to the class the week of Thanksgiving. There will be a workshop on paper reading, and use of LaTeX/Overleaf during a (cloudy) lab session. Please find your paper using: `https://ui.adsabs.harvard.edu/`). KLM must approve your paper choice.

If requested in advance, I am relaxed about extensions of up to a week. After a week you may submit assignments for 50% credit until the end of the semester, but you will not get feedback and you may not resubmit (see below). You will have the opportunity to recover 50% of lost points on Homework by discussing it with KLM in office hours (via Zoom possible). This need to happen within a week after you get the feedback.

FAQs

Will I learn how to use a telescope in this class?

Yes. Part of the labs will involve training on the Strawbridge Observatory 12" telescope, the Sunspotter Solar telescopes in the Library and remote use of a radio telescope.

What is astrophysics?

The use of physics to understand and learn about objects in the night sky. All areas of physics, as well as a lot of chemistry (and some biology) are important to the full understanding of astrophysical objects.

What's the difference between astronomy and astrophysics?

It's really just semantics in the modern useage. The most useful distinction is that there are lots of Amateur Astronomers (someone who as a hobby uses a telescope to view the skies), while it's much more unusual to be an Amateur Astrophysicist (someone who uses physics to interpret objects in the Universe). At Haverford the Astrophysics Major is basically the same as the Physics Major with an Astro emphasis, while the Astronomy Major has more astronomy and less core physics.

What is your favourite astronomical object?

Galaxies - the building blocks of the Universe, and fascinating in their own right.

Honour Code

Collaboration is an important part of science. You are strongly encouraged to work together and/or consult one another for work in this class. You are encouraged to consult any books necessary as well as resources on the internet. You must, however, turn in your own individual homework, and this must be written on your own. Copying and pasting (even parts of sentences) is not permitted and is a violation of the Honour Code. Good collaboration involves everyone understanding what is going on in the assignments. Therefore even if the basic solution is shared you must explain it in your own words (including mathematical words). Please credit your collaborators (list names). Please pay attention to your classmates to make sure no one is being left out of collaborative work.

You may not obtain materials from students who have taken this course in previous years, nor may you distribute your current materials to students not currently enrolled in this class. Please consult me if you have any questions.

Diversity and Inclusivity Statement

Science is sometimes considered objective and unrelated to people. However, science is done by people, and is historically built on a small subset of privileged voices. In this class, we will make an effort to read papers from a diverse group of scientists, but limits still exist on this diversity. I believe that integrating a diverse set of experiences is important for a more comprehensive understanding of science.

Our classroom should be a place where all members will be treated with respect. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. If something was said in class (by anyone including myself) that made you feel uncomfortable, please talk to me about it (anonymous feedback is always an option). I appreciate any opportunity to continue my learning about diverse perspectives.

Accommodation Statement

Your ability to thrive academically can be impacted by your personal well-being and a variety of stressors may impact you over the course of the semester. If the stressors are academic, I welcome the opportunity to discuss and address them with you in order to find solutions together. If you are experiencing challenges or questions related to emotional health, finances, physical health, relationships, learning strategies or differences, or other potential stressors, I hope you will consider reaching out to the many resources available on campus. These resources include CAPS (free and unlimited counseling is available) and many others. A full list can be found at https://www.haverford.edu/deans-office-student-life/offices-resources.

Haverford College is committed to creating a learning environment that meets the needs of its diverse student body and providing equal access to students with a disability. If you have (or may have) a learning difference or disability – including mental health, medical, or physical impairment – please contact the Office of Access and Disability Services at hc-ads@haverford.edu. The Director will confidentially discuss the process to establish reasonable accommodations. It is never too late.

Students who have already been approved to receive academic accommodations and want to use them in this course should share their accommodation letter, then meet with me as soon as possible to discuss how their accommodations can be implemented in this course. Please note that accommodations require advance notice in order to be successfully implement.

If, at any point in the semester, a disability or personal circumstances affect your learning in this course or if there are ways in which some aspect of the course could be adapted to facilitate full participation, please do not hesitate to reach out to me.

It is a state law in Pennsylvania that individuals must be given advance notice that they may be recorded. Therefore, any student who has a disability-related need to audio record this class must first be approved for this accommodation from the Director of Access and Disability Services and then must speak to me. Other class members need to be aware that this class may be recorded.

Draft Class Schedule

Stars and Planets

Week	Topic	Further Reading	Deadlines[1]
Week 1	What is Astrophysics. Introductions and plan	Ch1	
(Aug 31, Sep 2)	The Sun & The Solar System	Ch4, 14, 23.5	
Week 2	Telescopes and Observing	Ch2, 13	HW1 (Solar Physics)
(Sep 7, 9th)	Observations of Stars	Ch3, 4, 5	
	Evening Lab 1		
Week 3	Physics of Stars: Spectral Lines	Ch6, Appendix A, B	HW2 (Observing)
(Sep 14th)[2]			
Week 4	Physics of Stars: Hydrostatic Equilibrium	Ch15	First Lab Report[3]
(Sep 21st, 23rd)	Nuclear Fusion in Stars	Ch8, 18.1	
	Evening Lab 2		
(Sep 25th)	KINSC Summer Symposium		
Week 5	Stellar Lifecycles	Ch8.3, 18, 19.1,2	HW3 (Stars)
(Sep 28, 30th)	Pulsating Stars	(Ch 27)	
Week 6	White dwarfs, Neutron Stars and Pulsars	Ch19, 20	HW4 (Stars)
(Oct 5, 7th)	Supernovae and Stellar Mass Black Holes	Ch20	
	Evening Lab 3		

Fall Break

Week 7	Interstellar Medium (ISM)	Ch21	HW5 (Compact Objects)
(Oct 19th, 21st)	Star Formation	Ch22	
	Evening Lab 4		
(Oct 24th)	Fall Plenary		
Week 8	Planet Formation	Ch23	Second Lab Report
(Oct 26, 28th)	Exoplanets	Ch25	

[1] 2pm Thur unless noted
[2] No class on September 16th
[3] There will be four deadlines for Lab reports, and you may hand any one in at any deadline (but must hand one in for each deadline)

Galaxies and Cosmology

Week 9	The Milky Way	Ch26	HW6 (ISM and Milky Way)
(Nov 2nd, 4th)	The Milky Way		
	Evening Lab 5		
Week 10	Galaxies (normal)	Ch27	Third Lab Report
(Nov 9, 12th)	Galaxies		
Week 11	Galaxies (active)	Ch28	HW7 (Galaxies)
(Nov 16, 18th)	Large scale structure	Ch 29	
	Evening Makeup lab (if needed)		
Week 12	Student talks		Review papers due Tue
(Nov 23rd)	Thanksgiving Nov 25th	Holiday	
Week 13	Observational Cosmology	Ch31, 32, 30	Final Lab Report
(Nov 30th, Dec 2nd)			
Week 14	Physical Cosmology	Ch31, 30, 33	HW8 (Cosmology)
(Dec 7, 9th)			
Exam Week	Final Exam - Open Book, Take Home (4 hours allowed)		

Observing Projects

There will be 1-2 hours per week of workshops held outside of class five evenings throughout the semester. You must attend at least three of these (you may attend all). These workshops will cover the basics of observational astronomy, including navigating the skies, the use of the 12" telescope and the Solar telescopes and remote use of a radio telescope. We will schedule these during the first week of class based on your availability. Some labs will also depend on the weather, so exactly what happens each workshop will be determined as we go.

On one cloudy evening we'll use the time to discuss tactics for reading papers, as well as practice use of LaTex (using Overleaf.com) to write papers the way professional astronomers (and other types of physicists) do it.

Four observing projects will be assigned during the term. There will be four deadlines for these projects, and you may hand any one in at any deadline (but must hand one in for each deadline).

You may use the Solar telescopes on any sunny day, but please use them only in the vicinity of the Observatory (unless you have special permission) and always return them to the library.

Students must work in teams of two or three at the 12" telescope. After being checked out on the telescope, students are allowed to sign up for independent use as long as they are accompanied by another qualified observer. WARNING: The weather is a formidable foe. Even though the actual number of hours you spend observing will be few, if you don't get your optical Observing done early in the semester you may have to be "on call" for much of the time. You should plan to give optical observing top priority on clear evenings to ensure successful completion of the projects.

1	Unaided Eye Observing	You will learn how to use Stellarium or other software to work out what is visible on a given night, and explain the annual and daily motions of the Sun, Moon, stars and planets as observed from Earth. During one of the evening sessions you will point out three constellations to the professor or TA, and comment on the phase of the Moon and any visible planets. The report will comprise a narrative description of this process (how you selected your targets, comments and challenges in pointing them out).
2	Observing with the 12"	You will learn to observe with the 12" and select (using Stellarium or in consultation with the Professor or TA) and point the telescope at two interesting objects (on a clear evening session). This may be done collaboratively, but you should use the handset for at least one object. The report will be a narrative description of this process, including your explanation of how to observe with the 12".
3	Solar Observing	You will make use of one of the small solar telescopes (in the library) to observe the Sun, measure it's angular diameter to estimate its physical size, record the Sunspot number to compare to archival data, and use the motions of sun spots to estimate its rotation rate. Observations for this project must be completed over a period of several continuous sunny days when a sunspot is visible on the Sun.... You will be shown how to use archival data as a backup if the weather (Solar or Earth based) does not co-operate.
4	Galaxies and Cosmology	You will learn how to use a radio telescope remotely to observe the HI 21cm spectral line coming from an external galaxy. You will use this observation to estimate the dark matter fraction of the galaxy, and contribute your measurement of the redshift of the galaxy, along with an estimate of its distance to a class database to create a Hubble diagram which should demonstrate the expansion of the Universe. This project is not weather dependent - radio observing can happen through clouds.